REMARKS

Drying semiconductor wafers and similar devices presents special challenges, as is well known in the art. The drying must be controlled to reduce or prevent contaminating particles and residues from depositing or remaining on the device surfaces. The drying must be complete to ensure that water drops are not left behind to evaporate, as evaporation tends to leave contaminating deposits (see the application at 0007-0009). Marangoni-type processes have been used for several years in drying wafers and other substrates. While Marangoni-type processes represent a significant advance over prior processes, disadvantages remain concerning drying speed, cost, performance, and environmental factors (see Mehmandoust, US2001/0047595 A1, at 0009). Similarly, drying techniques using hydrofluoroether, such as described in Ferrell *et al.*, U.S. Patent No. 5,974,689, also have various disadvantages, as described in Mehmandoust at 0010.

The claims describe methods for cleaning and drying workpieces, such as semiconductor wafers, which largely overcome several of the disadvantages associated with other techniques (as described, for example, in Mehmandoust at 0003-0011). The claims describe a surface tension drying process wherein evaporation (and its associated disadvantages) are avoided. As described in the claims, the workpiece is dried as it is removed form an aqueous solution. No follow-on displacement step is needed. Sonic energy is applied to the workpiece as it is removed from the bath of liquid, in combination with the surface tension drying technique. This provides several beneficial effects. Continuing to apply sonic energy while withdrawing the workpieces provides an energetic environment, which helps to thin the boundary layer of liquid at

the gas/liquid interface. This increases interaction between the liquid and the gas to promote drying. It also helps to prevent particle re-adhesion at the interface.

Turning now specifically to the prior art, initially, Mehmandoust teaches against making the combination of Mehmandoust and Ferrell *et al.* (U.S. Patent No. 5,974,689). Ferrell *et al.* describes a drying process which relies purely on displacement/evaporation of hydrofluoroether. Column 2, lines 2-24; column 3, lines 21-50; column 5, lines 15-27; and column 6, line 47 – column 7, line 30. While Mehmandoust also uses hydrofluoroether, Mehmandoust explains at 0010 that larger amounts of hydrofluoroether (HFE) are required, making recycling the HFE necessary. Accordingly, in view of the way that the principle reference Mehmandoust characterizes the (pure HFE) processes of the secondary reference Ferrell *et al.*, the principle reference Mehmandoust itself teaches away from the combination of Mehmandoust and Ferrell *et al.*

Use of HFE is the common linking element between Mehmandoust and Ferrell et al. However, HFE is irrelevant in the claimed process. This further demonstrates lack of motivation to combine the references.

Moreover, the combination of Mehmandoust and Ferrell *et al.* does not render the claims obvious, for the following reasons. Mehmandoust discloses use of a polar organic compound, such as isopropyl alcohol (IPA), <u>but only in combination with a hydrophobic organic compound</u>, such as HFE. Neither compound is used separately. Indeed, 0004-0010 of Mehmandoust outlines in detail the disadvantages of using IPA and HFE separately. Mehmandoust consistently describes use of both IPA and HFE together. See Mehmandoust at 0003, 0012, 0017, and 0094. The IPA vapor increases the wet-ability of the disks 104 and promotes removal of water. Surface tension

differences promote the separation of water from the disk. Mehmandoust at 0088. HFE vapor further promotes the separation of water from the disk, by displacing the water. The HFE penetrates between the water film and the disk and remains on the disk until evaporated. The presence of HFE on the disk prevents the condensation of water vapor on the disk. The water displacing effect of HFE can reduce the quantity of isopropyl alcohol required for drying. Mehmandoust at 0089. Accordingly, Mehmandoust teaches the use of IPA, but only in combination with HFE. Hence, Mehmandoust achieves drying via a mechanism different from the claims, which describe pulling aqueous solution off of the workpiece. From the description at e.g. 0089 in Mehmandoust, it is apparent that the water on the disk in Mehmandoust is ultimately removed via the displacement/evaporation of HFE, rather than the pulling of the aqueous solution, as described in the pending claims.

As noted at page 3 of the 05/12/2005 Office Action, Mehmandoust does not teach sonic agitation. On the other hand, Applicant does not here dispute that the use of ultrasonic energy for particle removal may be well known in the art. However, even if the ultrasonic energy element of Ferrell *et al.* (or other prior art) is combined with Mehmandoust, the claims are not rendered obvious. Initially, there is nothing in the prior art to suggest that providing sonic agitation in a Mehmandoust type of process would provide any advantage. Moreover, even in Ferrell *et al.*, the ultrasonics are described as "optional." See Ferrell *et al.*, Fig. 2, step 33; column 3, line 5; and column 3, line 54.

While Ferrell *et al.* discloses use of ultrasonic vibrations, Ferrell *et al.* does not disclose the claimed step of <u>continuing sonic agitation while the liquid-vapor or aerosol</u>

<u>interface passes across the workpiece surface</u>. This is clear from the following passages in Ferrell *et al.*:

> "A workpiece 17A, 17B, 17C is upwardly withdrawn from the first liquid 13, and an exposed surface of the workpiece is sprayed with a sheet of a second processing liquid (not explicitly shown in Fig. 1) to achieve rapid workpiece drying and/or cleaning. The second liquid preferably includes a hydrofluoroether. . . " Column 3, lines 16-22.

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> ". . . and the second liquid is optionally subjected to ultrasonic vibrations <u>while the workpiece is immersed</u>." Column 3, lines 53-55 (emphasis added).

* * *

> "FIG. 2 is a flow chart illustrating one embodiment of a suitable procedure for practicing the invention. In step 31, a workpiece (electronic part or parts) is fully immersed in a (preferably inert) first processing liquid, such as deionized (DI) water or IPA that is prepared in a selected temperature in the range T=10-90° C., <u>for an immersion time interval (optional) of selected length in the range Δt=0-600 seconds.</u> In step 33, the first liquid is optionally subjected to ultrasonic wave motion at one or more selected ultrasonic frequencies in the range 20-750 kHz <u>for most or all of the immersion time interval. In step 35, after the time interval of immersion is</u>

> <u>completed, the workpiece is slowly withdrawn from the bath of the first processing liquid</u>, preferably at a linear rate of withdrawal of between 0.5 and 5 cm/sec and preferably in a clean room or inert environment." Col. 4, lines 11-21 (emphasis added).

Thus, Ferrell *et al.* clearly suggests that ultrasonics are used at most only in the time interval while the workpiece is fully immersed. As described in the passage above, no ultrasonics is used <u>after</u> the immersion interval, i.e., during the withdrawal step.

The passage set forth below similarly leads to the same conclusion, i.e., that Ferrell *et al.* does not teach continuing to apply sonic agitation while the liquid-vapor interface passes across the workpiece surface, as claimed (e.g., as the workpiece is lifted out of the bath of aqueous solution).

> "The workpiece 91 is immersed in the second liquid 95 for a selected immersion time interval, preferably in the range 5-120 sec, or longer if desired. <u>For at least a portion of the immersion time interval (e.g., at least 5-10 sec), the workpiece 91 is subjected to ultrasonic vibrations generated by an ultrasonic wave generator 97 that is positioned inside, or outside and</u> contiguous to, the tank 93. The ultrasonic vibrations help the low surface tension second liquid 95 displace material residues, air and first liquid on exposed surfaces of the workpiece 91. <u>After the immersion time</u>

interval ends, the workpiece 91 is withdrawn from the second liquid 95, as shown in FIG. 7B, at a linear withdrawal rate in a preferred range of 0.5-5 cm/sec, into a controlled atmosphere, such as a vacuum, a clean room or an atmosphere containing primarily N_2 or CO". Col. 7, line 12-26 (emphasis added).

Accordingly, even if Ferrell *et al.* is combined with Mehmandoust, the claims are patentable over that combination, at least because the combination of prior art does not suggest the continuing sonic agitation step.

In view of the foregoing, it is submitted that the claims are in condition for allowance. A Notice of Allowance is requested.

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